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FORECASTING SYSTEMS TECHNICAL NOTE NO.9

SUMMARY of TROPICAL CYCLONE ACTIVITY and FORECASTS in the 1997 NORTHERN HEMISPHERE SEASON

J.T.HEMING

JUNE 1998

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1. INTRODUCTION

A summary of tropical cyclone activity in the northern hemisphere for the 1997 season is presented below together with an assessment of the performance of the global model in predicting the tracks of these tropical cyclones.

Tropical cyclones are experienced in the North Pacific, North Atlantic and North Indian Oceans and nearby tropical seas. For the purpose of tropical cyclone verification the northern hemisphere is divided in to four basins; the North-West Pacific (west of 180°E to the Malay Peninsula), the North-East Pacific (east of 180°E), the North Atlantic and the North Indian Ocean (west of the Malay Peninsula). Mean error statistics for each basin are presented together with a table of statistics for the whole northern hemisphere. The global model produces a 6-day forecast every 12 hours. Verification is performed at 24 hour intervals up to forecast time T+120.

The global model resolution in operation during the season was 1.25°x 0.83°x 19 levels. This is equivalent to a horizontal resolution of 139km x 93km at the equator. The tropical cyclone verification scheme identifies the centre of a tropical cyclone in the model by locating a local maximum of relative vorticity at 850hPa. A surface fitting technique is used to locate the centre accurately.

The terms used in the statistics tables are explained below :-

Possibly verified - No. of forecasts fulfilling requirements 1, 2 & 4 below.
Detection Rate - Percentage of possibly verified forecasts which also fulfil requirement 3 below.
Mean DX - Mean of positional errors in the East-West direction.
Mean DY - Mean of positional errors in the North-South direction.
Mean AT - Mean of positional errors in the Along Track direction.
Mean CT - Mean of positional errors in the Cross Track direction.
Skill - Percentage skill of model against CLIPER.
Mean DPE - Mean of direct positional errors.
All errors are measured in kilometres except where indicated.

(*) 1. Observed maximum wind at least 31 knots at the verifying time.
2. Forecast tropical cyclone centre equatorwards of 45 degrees.
3. Forecast tropical cyclone centre relative vorticity above a critical limit for verification (0.55×10^{-4} per second).
4. Observation within 6 hours of verifying time present for use in verification.

Forecast skill is defined as:-
(CLIPER DPE - Model DPE)/ CLIPER DPE x 100%

Positive skill indicates the model forecast is better than CLIPER.
Negative skill indicates the CLIPER forecast is better than the model.

A diagrammatic explanation of other error statistics and their sign conventions can be found in Appendix A. Full details of the TC verification scheme can be found in *nwp* Gazette, Vol.1, No.2, December 1994.

Advisory positions from JTWC Guam, NHC Miami and CPHC Honolulu are used as verifying observations of storm location when track verification is carried out immediately after a storm has ended. Best track data from these centres has been obtained for this season's storms and the track forecasts verified again. Statistics for verification against best-track observations are presented in detail. Some statistics for verification against real-time observations are included for the purposes of a comparison. Some mean error statistics for last season are also included for the purposes of a comparison. Forecast tracks are only verified when a depression reaches tropical storm status.

2.TROPICAL CYCLONE ACTIVITY

	NWP	NEP	NAT	NI	TOTAL
Total number active 1996	43(30)	13(8)	13(13)	8(8)	77(59)
Total number active 1997	32(30)	22(17)	8(7)	5(5)	67(59)

Basin name abbreviations:- NWP = North-West Pacific (west of 180°E)
NEP = North-East Pacific (east of 180°E)
NAT = North Atlantic
NI= North Indian

The number in brackets indicates the number of depressions which reached tropical storm status (maximum sustained wind above 33 knots).

3. SUMMARY OF ALL NORTHERN HEMISPHERE STORMS

3.1 North-West Pacific Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	396	335	279	230	189	150
Detection Rate (%)	100	100	98	94	93	89
Mean DX	-3	-24	-61	-62	-81	-22
Mean DY	11	54	51	10	-20	30
Mean AT	4	11	6	-18	-77	34
Mean CT	14	15	7	24	79	172
Mean Skill (%)	****	0	28	38	****	****
* 1996 Skill (%)	****	-8	30	39	****	****
RT Skill (%) #	****	21	35	41	****	****
Mean DPE	55	153	259	396	621	767
* 1996 DPE	56	160	263	396	509	631
RT DPE #	42	152	262	400	619	766

* DPE and skill for all North-West Pacific storms in 1996 season

DPE and skill in 1997 calculated using real time observations as opposed to best track.

Comments :

A plot of the observed tracks of all storms in this basin can be found in Fig. 1.

The same number of tropical storms formed this season as in 1996 in the North-West Pacific basin. However, the distribution of the storms shifted towards the east and a higher proportion underwent recurvature. Forecast errors were near to last seasons values up to T+72, but higher at longer forecast ranges. This may be due to a higher proportion of storms recurving increasing the likelihood of large longer range errors. Skill scores were similar to last season. There was a slight right-of-track bias in forecasts. The detection rate for storms was very good with 89% of storms being successfully retained 5 days into the forecast.

Figs. 2 and 3 show forecast errors and skill scores for the last few seasons.

3.2 North-East Pacific Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	148	115	85	65	49	39
Detection Rate (%)	100	95	82	80	69	64
Mean DX	6	-6	21	81	188	241
Mean DY	-8	-32	-74	-100	-149	-281
Mean AT	-17	-38	-104	-180	-269	-317
Mean CT	6	-3	-17	-6	27	42
Mean Skill (%)	****	7	28	25	****	****
* 1996 Skill (%)	****	-53	-1	1	****	****
RT Skill (%) #	****	19	38	31	****	****
Mean DPE	51	141	236	362	436	541
* 1996 DPE	76	209	319	340	****	****
RT DPE #	46	142	239	363	440	545

* DPE and skill for all North-East Pacific storms in 1996 season
# DPE and skill in 1997 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 4.

There were twice as many storms this season than in the inactive 1996 season in the North-East Pacific basin. Activity spread further west and north than in 1996. Forecast errors were near to or higher and skill scores were much higher than last season. There was a marked slow bias in forecasts. The detection rate, which is normally poor in this basin, improved, but was still just 64% at T+120.

Figs. 5 and 6 show forecast errors and skill scores for the last few seasons.

3.3 North Atlantic Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	49	34	24	18	15	17
Detection Rate (%)	100	94	88	83	87	71
Mean DX	-8	-64	-114	-198	-266	-280
Mean DY	-6	-14	53	51	-3	-12
Mean AT	-7	-59	0	-139	-226	-220
Mean CT	-2	-47	-176	-215	-141	-78
Mean Skill (%)	****	26	36	50	****	****
* 1996 Skill (%)	****	4	31	41	****	****
RT Skill (%) #	****	34	44	50	****	****
Mean DPE	50	169	264	361	402	384
* 1996 DPE	52	151	272	368	488	671
RT DPE #	40	170	261	366	409	394

* DPE and skill for all North Atlantic storms in 1996 season
\# DPE and skill in 1997 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 7.

The 1997 season was a relatively inactive one in the North Atlantic basin. Forecast errors were near to last seasons values up to T+72 and lower at longer forecast ranges, although the number of forecasts to verify at longer ranges was small. Skill scores were very high. Forecasts tended to have a slow and left-of-track bias. Detection rates were better than last season, but still only 71% at T+120.

Figs. 8 and 9 show forecast errors and skill scores for the last few seasons.

3.4 North Indian Basin Storms

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	42	33	24	17	12	8
Detection Rate (%)	100	100	96	88	100	100
Mean DX	-2	-5	-31	-59	-210	-237
Mean DY	12	-12	-56	-62	-105	49
Mean AT	-3	-46	-79	-86	-90	98
Mean CT	9	21	53	60	69	179
Mean Skill (%)	****	-24	-9	3	****	****
* 1996 Skill (%)	****	-28	18	****	****	****
RT Skill (%) #	****	13	13	19	****	****
Mean DPE	67	178	327	484	606	518
* 1996 DPE	76	188	282	119	459	617
RT DPE #	50	178	329	479	607	512

* DPE and skill for all North Indian storms in 1996 season
\# DPE and skill in 1997 calculated using real time observations as opposed to best track.

Comments :
A plot of the observed tracks of all storms in this basin can be found in Fig. 10.

There were just five tropical storms in the North Indian basin this season. Forecast errors were above last season's values at T+48, T+72 and T+96. The model only showed skill over CLIPER at T+72. There was a right-of-track bias in forecasts.

Figs. 11 and 12 show forecast errors and skill scores for the last few seasons.

3.5 Combined Statistics for whole Northern Hemisphere

Table of Mean Error Statistics

	T+0	T+24	T+48	T+72	T+96	T+120
Possibly Verified	635	517	412	330	265	214
Detection Rate (%)	100	98	94	91	89	83
Mean DX	-1	-21	-47	-44	-59	-12
Mean DY	5	27	22	-11	-42	-16
Mean AT	-2	-7	-19	-56	-114	-29
Mean CT	10	8	-5	8	59	137
Mean Skill (%)	****	1	27	36	****	****
* 1996 Skill (%)	****	-8	30	39	****	****
RT Skill (%) #	****	21	35	40	****	****
Mean DPE	55	153	259	393	581	698
* 1996 DPE	59	164	268	382	503	640
RT DPE #	43	153	262	396	580	699

* DPE and skill for all Northern hemisphere storms in 1996 season

\# DPE and skill in 1997 calculated using real time observations as opposed to best track.

Comments :

Forecast errors for the whole northern hemisphere in 1997 were similar to those for 1996 up to T+72, but slightly higher at longer forecast ranges. The high number of recurving storms in the North-West Pacific may account for this. Skill scores were near to last season's values. There was a slow bias in forecasts and a right-of-track bias in T+96 and T+120 forecasts. This indicates a tendency to recurve storms too quickly. 83% of forecasts successfully retained storms centres 5 days into the forecast.

On average, there was only a small difference between forecast positional errors derived using real time observations and those derived using best track observations. T+24 skill scores tended to be much lower when using best track data than real time data. The reason for this is that when best track data are used, it is not only the verifying observations that are different, but CLIPER forecasts are also recalculated. Since the past observations used to calculate CLIPER forecasts are much better, CLIPER will improve (particularly at T+24 which is more heavily weighted towards persistence). Hence skill scores will reduce. Consequently, comparisons of skill scores derived using real time and best track data must be treated with caution. All figures for 1996 quoted in this paper are using best track data. Prior to 1995 only real time data were used in verification.

Figs. 13 to 16 show forecast errors, skill scores, along and cross track errors over the last few seasons. The level of improvement in forecasts seen in 1995 and 1996 after the introduction of the new initialisation scheme has been maintained in 1997.

Further Tropical Cyclone Information

The Met. Office pages on the World Wide Web contain information on tropical cyclone forecasting at the Met. Office. Monthly bulletins of tropical cyclone activity and forecasts are held together with observed and forecast track information of recent storms, track prediction error statistics, lists of names, images, movies and photographs and details of advances made in tropical cyclone track prediction at the Met. Office.

The Met. Office web site is:- **http://www.met-office.gov.uk**
Tropical Cyclone information can be found under the section "The weather & how we forecast it".

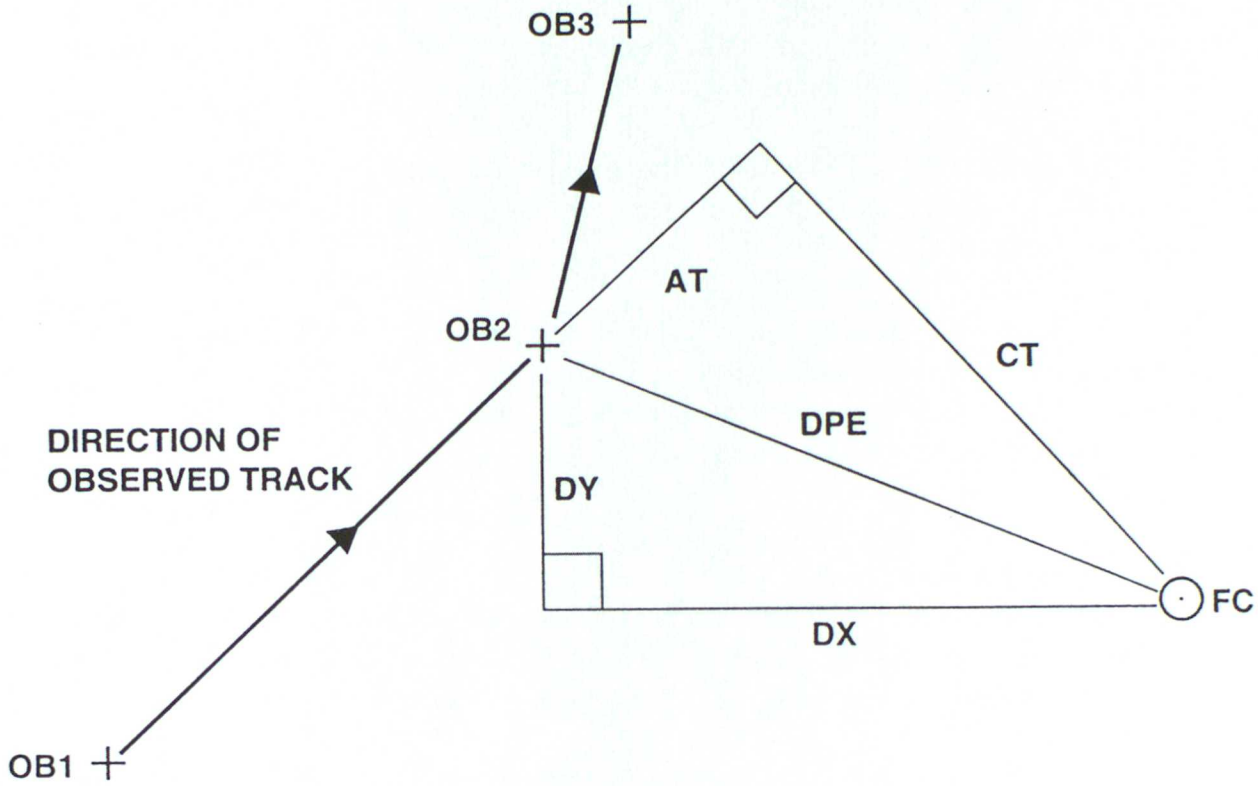
The information above is also available on the Met. Office internal Web:- **http://www-cf/~cfss/tchome.html.**
Contact Julian Heming (**jheming@meto.gov.uk**) for further information on tropical cyclone forecasting at the Met. Office.

Acknowledgements

CLIPER models for various basins were supplied by Mr.S.Lord, NMC, Washington, USA and Mr.C.Mauck, FNOC, Monterey, USA. GrADS software used to produce track plotting charts was supplied by Mr.S.Lord and Dr.M.Fiorino.
Best track observations for the northern hemisphere were obtained from the National Hurricane Center, Miami and the Joint Typhoon Warning Center, Guam.

APPENDIX A

Diagrammatic Explanation of Forecast Errors



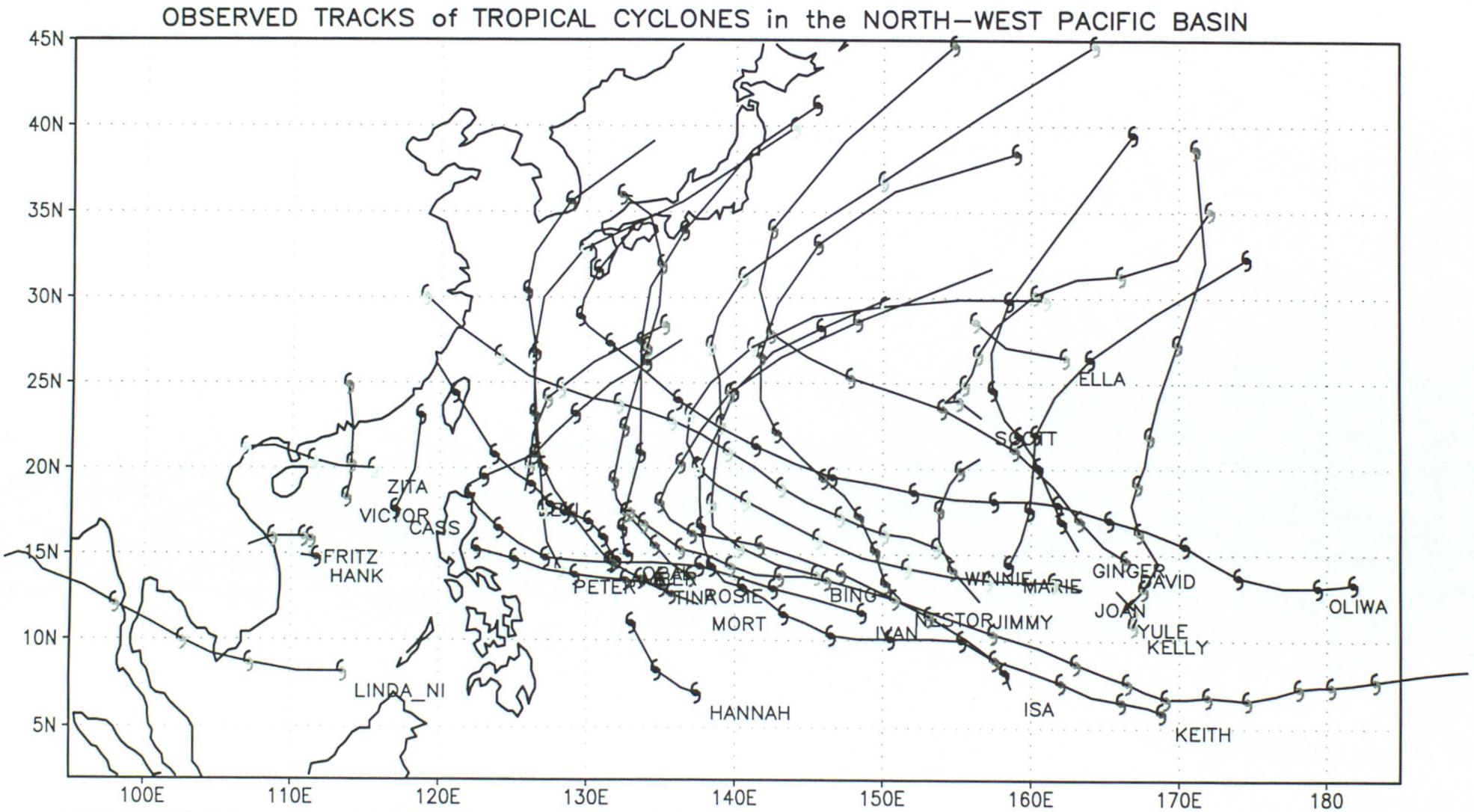
OB1-3 : Observed positions
FC : Forecast position verifying against observation OB2
DPE : Direct positional error
DX : Error in the East-West direction
DY : Error in the North-South direction
AT : Error in the Along Track direction
CT : Error in the Cross Track direction

All errors are measured in kilometres

Sign Conventions

DPE values are always positive.
DX errors are positive if the forecast position lies eastwards of the observed position.
DY errors are positive if the forecast position lies polewards of the observed position.
AT errors are positive if the forecast position lies ahead of the observed position along the tropical cyclone track.
CT errors are positive if the forecast position lies right of the observed track in the northern hemisphere and left of the observed track in the southern hemisphere.

Figure 1



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NESTOR 970608	OPAL 970616	PETER 970624	ROSIE 970720	SCOTT 970728	TINA 970731
VICTOR 970801	WINNIE 970810	YULE 970818	ZITA 970821	AMBER 970822	BING 970829
CASS 970829	OLIWA 970903	DAVID 970913	ELLA 970922	FRITZ 970923	GINGER 970925
HANK 971003	IVAN 971014	JOAN 971015	KEITH 971028	LINDA_NI 971101	MORT 971112
PAKA 971203					

KEY to DATE of FIRST SYMBOL

24 HOURLY BEST TRACK OBSERVED POSITIONS

SYMBOLS REPRESENT 00Z POSITIONS

Figure 2

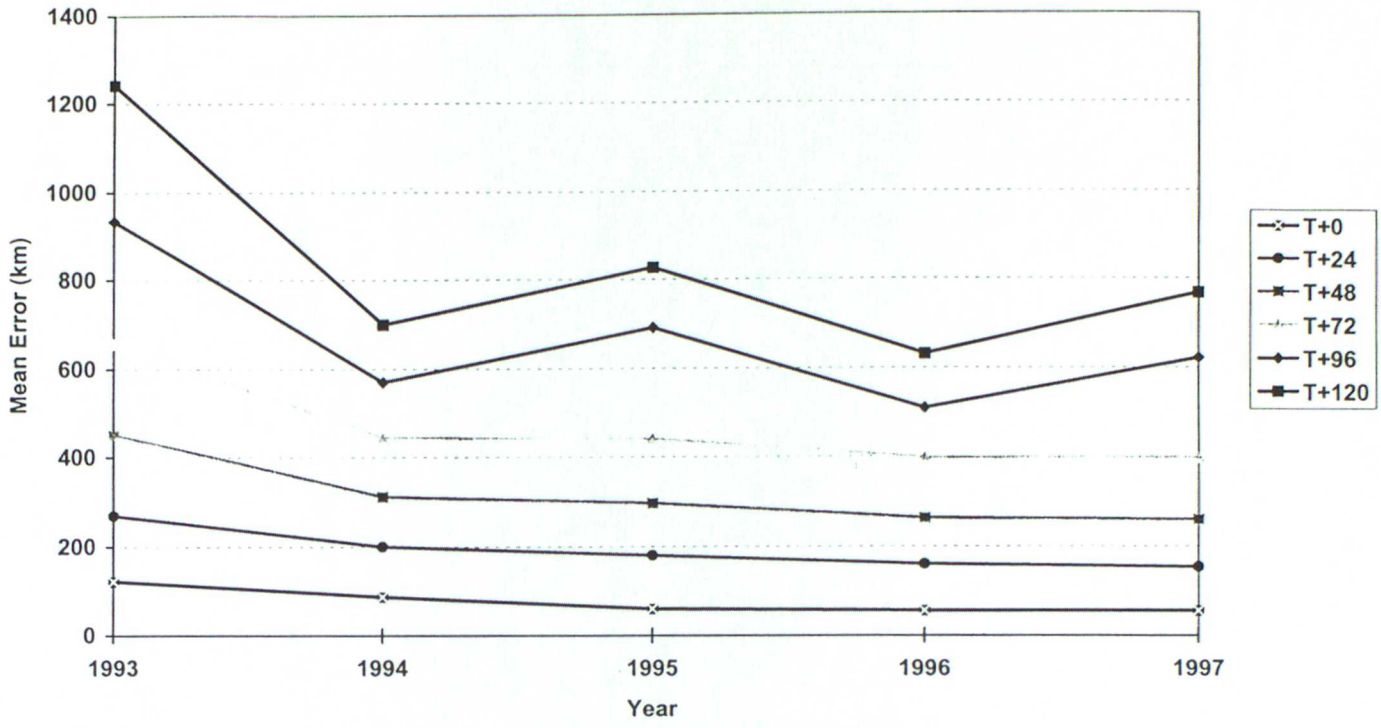


Figure 3

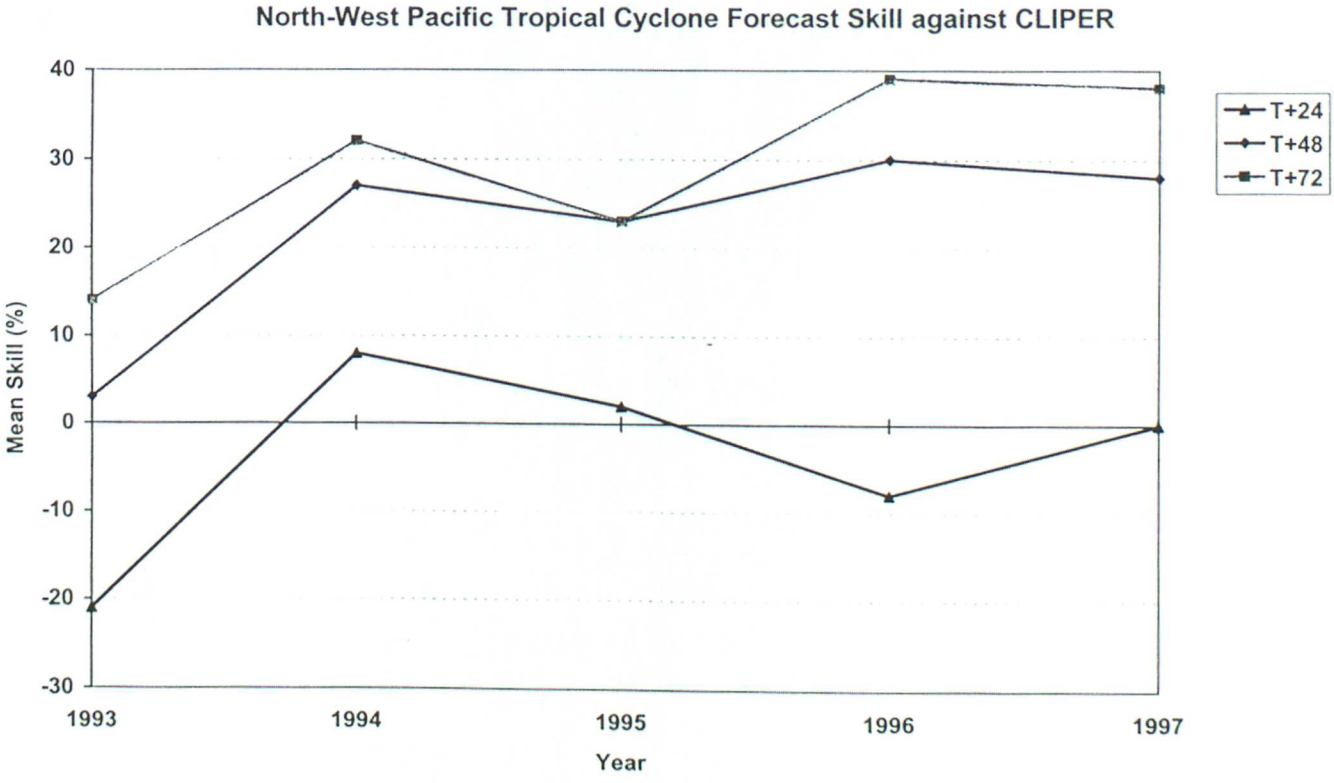


Figure 4

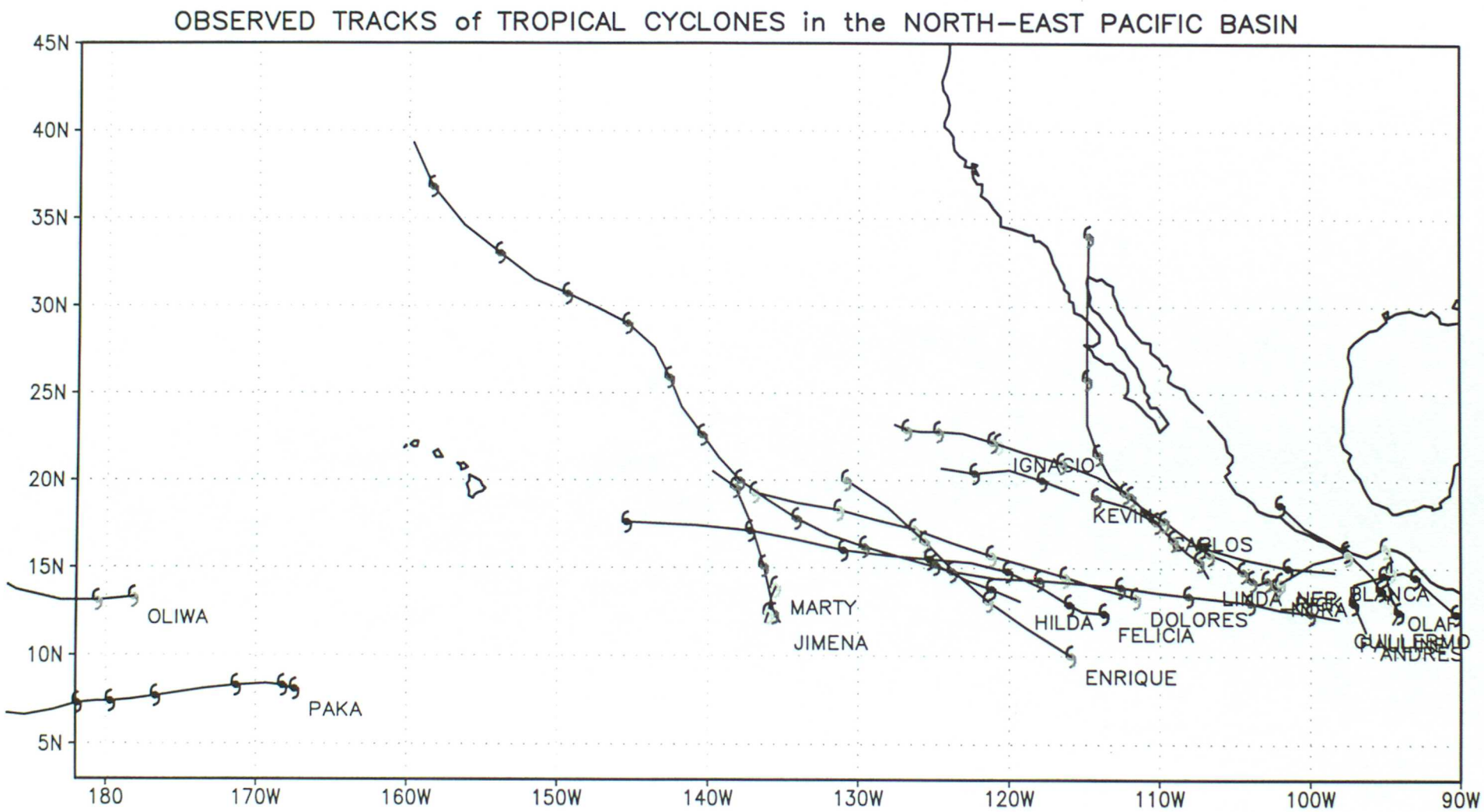

OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH–EAST PACIFIC BASIN
45N
40N
35N
30N
25N
20N
15N
10N
5N
180
170W
160W
150W
140W
130W
120W
110W
100W
90W
OLIWA
PAKA
MARTY
JIMENA
IGNACIO
KEVIN
CARLOS
HILDA
DOLORES
FELICIA
ENRIQUE
LINDA
BLANCA
OLAF
GUILLERMO
ANDRES
ANDRES 970603
BLANCA 970611
CARLOS 970626
DOLORES 970706
ENRIQUE 970713
FELICIA 970716
GUILLERMO 970801
HILDA 970813
IGNACIO 970818
JIMENA 970827
KEVIN 970905
LINDA_NEP 970911
MARTY 970914
NORA 970917
OLAF 970927
OLIWA 970903
PAULINE 971007
RICK 971109
PAKA 971203
KEY to DATE of FIRST SYMBOL
24 HOURLY BEST TRACK OBSERVED POSITIONS
SYMBOLS REPRESENT 00Z POSITIONS

Figure 5

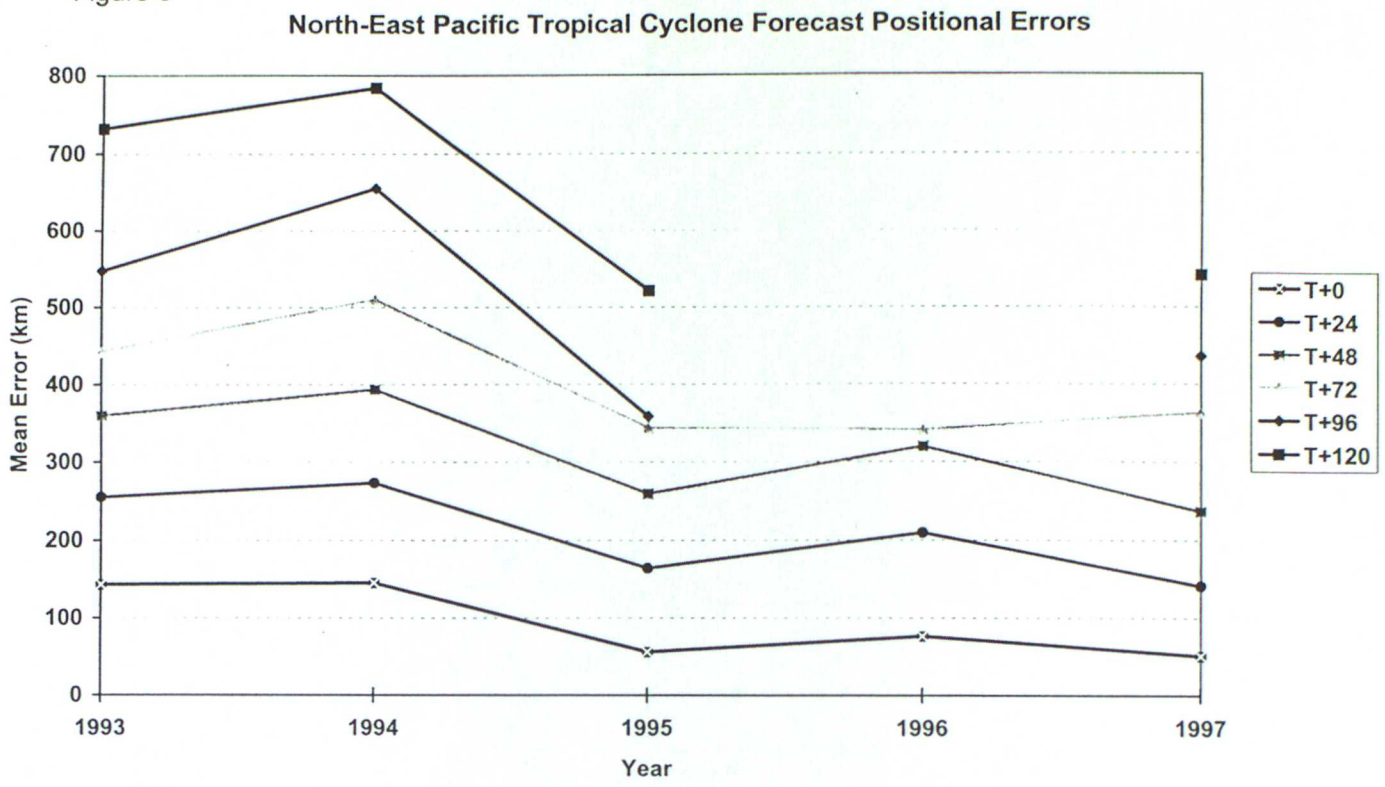


Figure 6

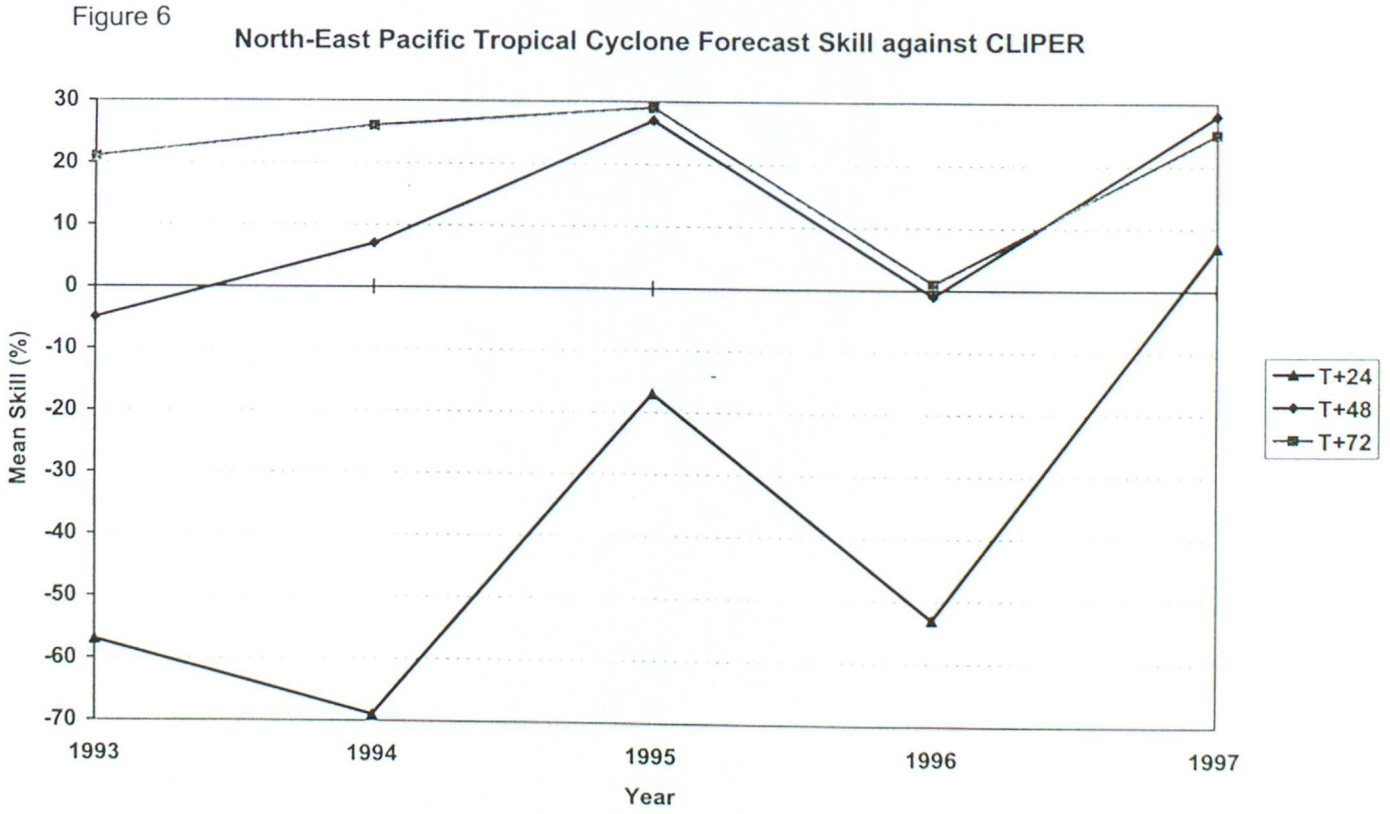
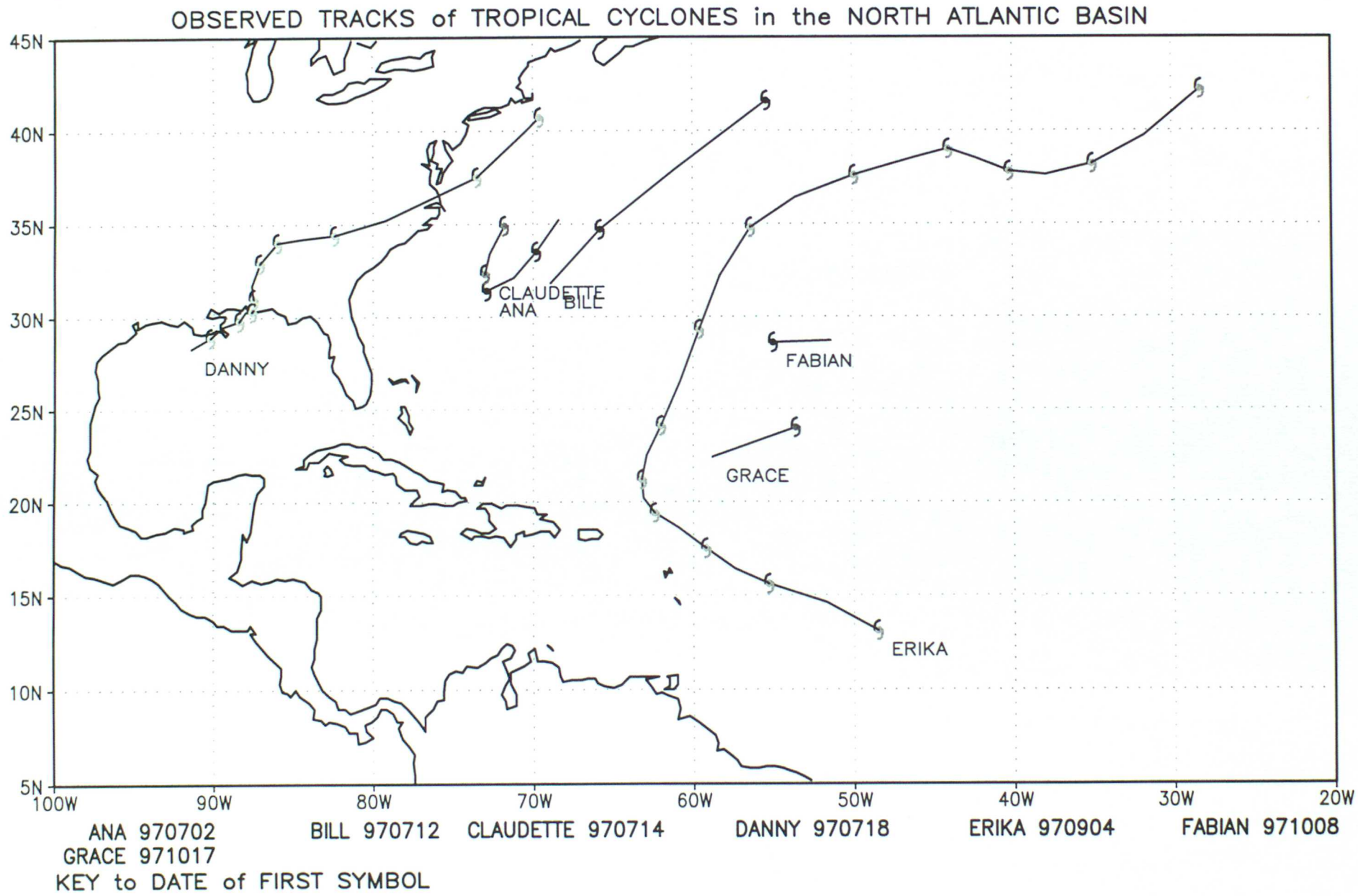


Figure 7


OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH ATLANTIC BASIN
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35N
30N
25N
20N
15N
10N
5N
100W
90W
80W
70W
60W
50W
40W
30W
20W
CLAUDETTE
ANA
BILL
DANNY
FABIAN
GRACE
ERIKA
ANA 970702
BILL 970712
CLAUDETTE 970714
DANNY 970718
ERIKA 970904
FABIAN 971008
GRACE 971017
KEY to DATE of FIRST SYMBOL
24 HOURLY BEST TRACK OBSERVED POSITIONS
SYMBOLS REPRESENT 00Z POSITIONS

Figure 8

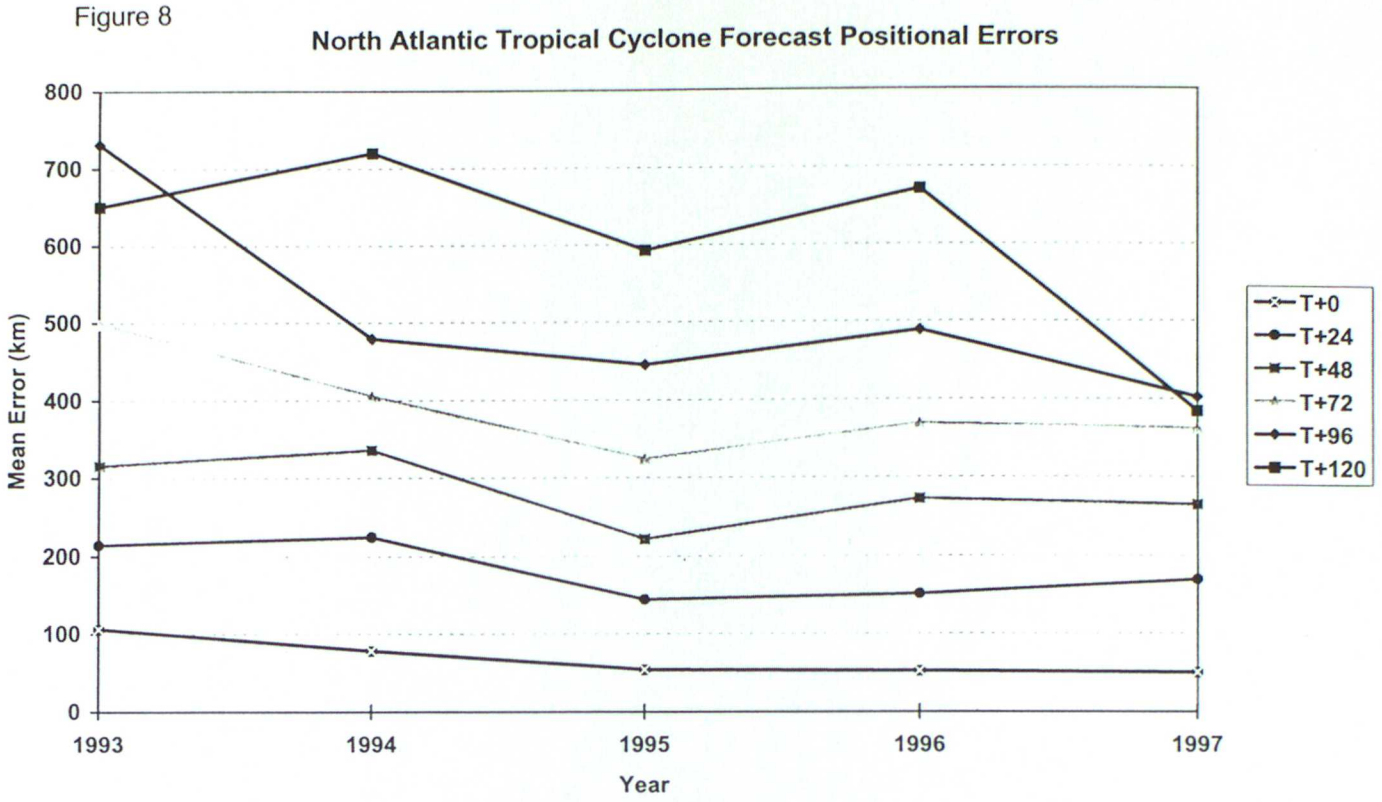


Figure 9

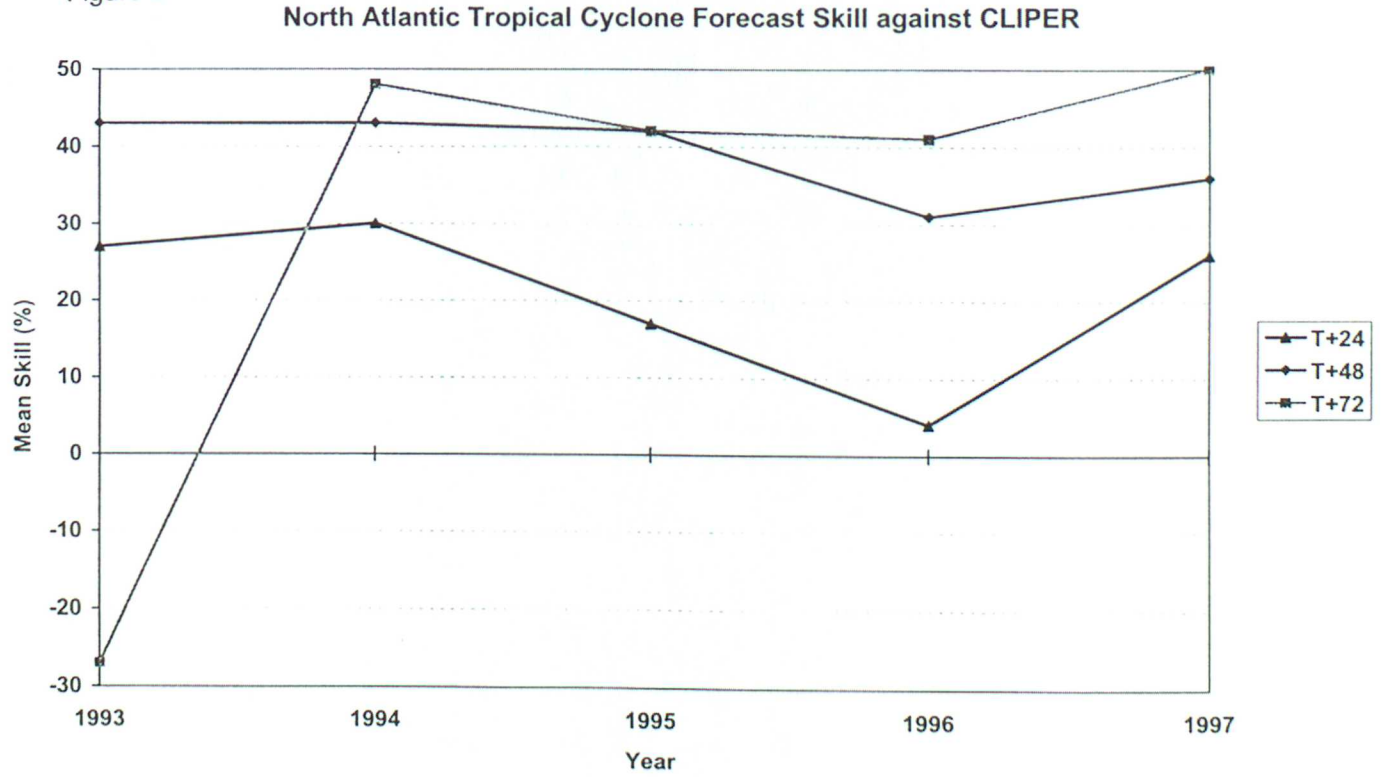
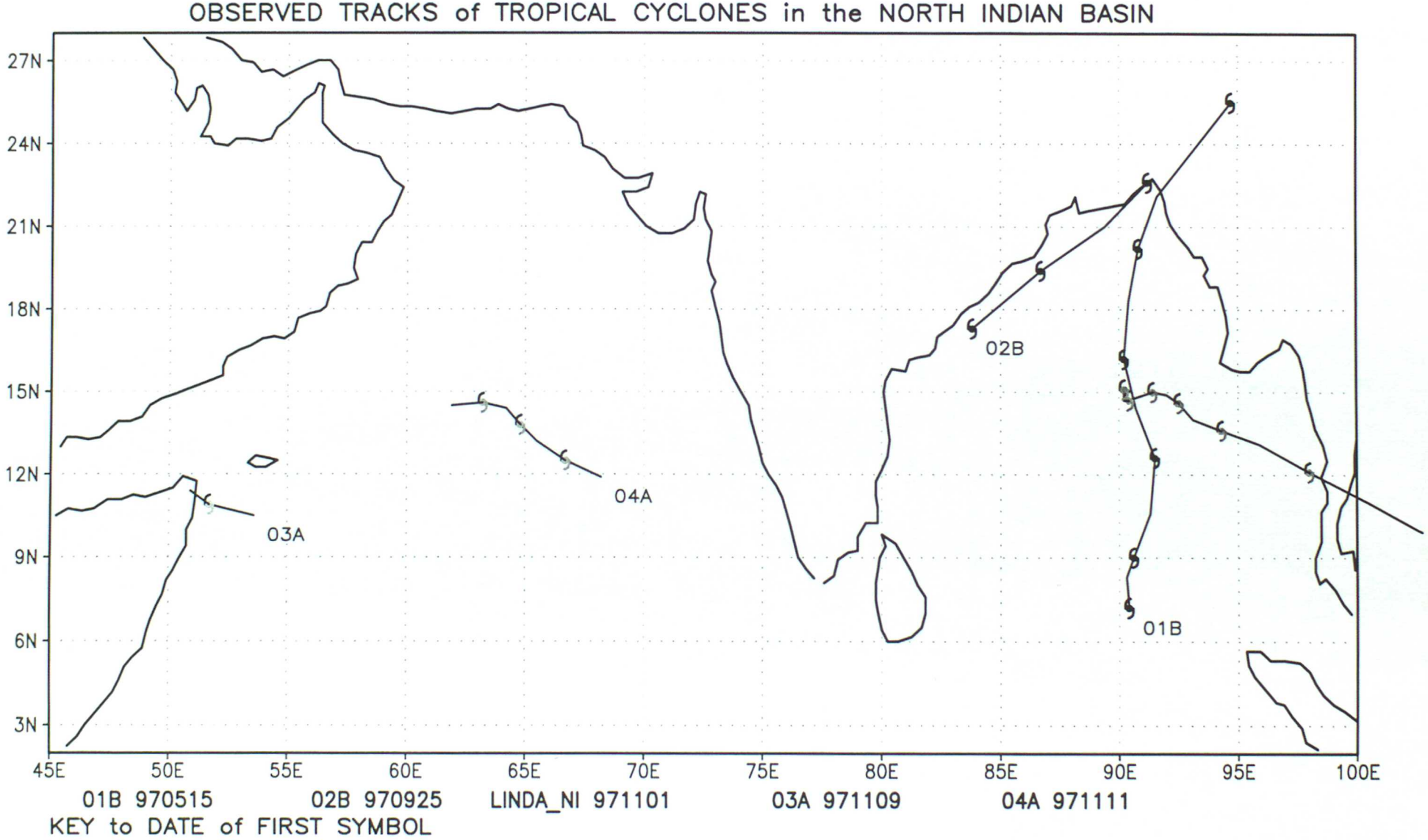


Figure 10


OBSERVED TRACKS of TROPICAL CYCLONES in the NORTH INDIAN BASIN
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21N
18N
15N
12N
9N
6N
3N
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50E
55E
60E
65E
70E
75E
80E
85E
90E
95E
100E
02B
04A
03A
01B
01B 970515
02B 970925
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KEY to DATE of FIRST SYMBOL
24 HOURLY BEST TRACK OBSERVED POSITIONS
SYMBOLS REPRESENT 00Z POSITIONS

Figure 11

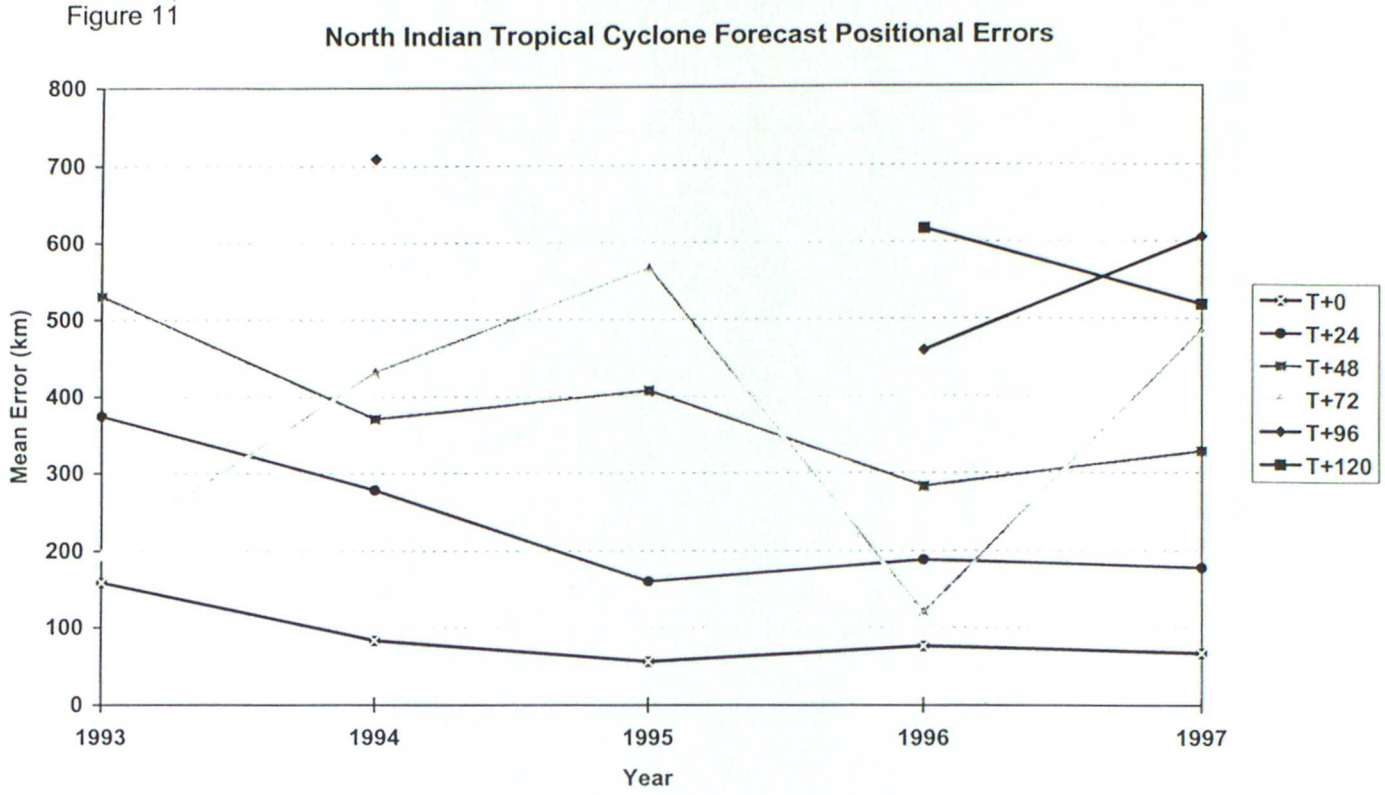

Figure 12

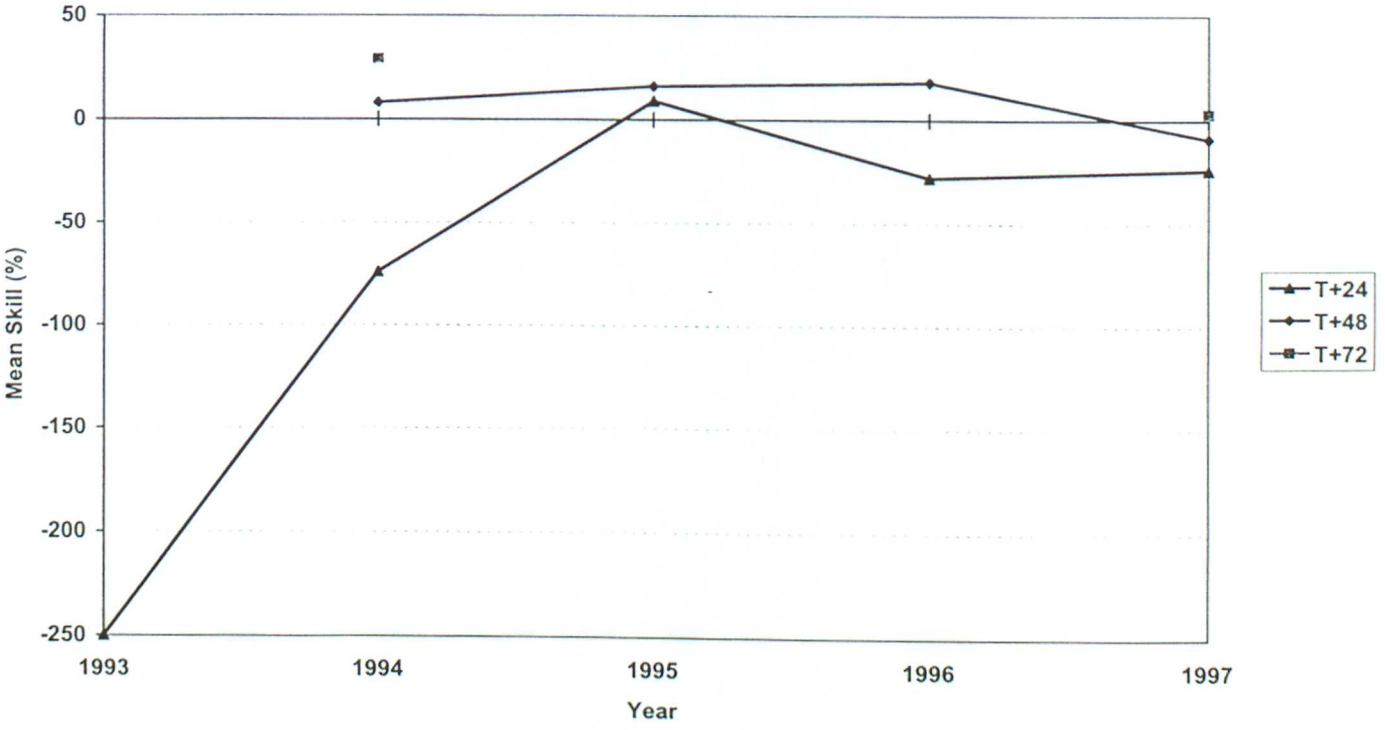

Figure 13

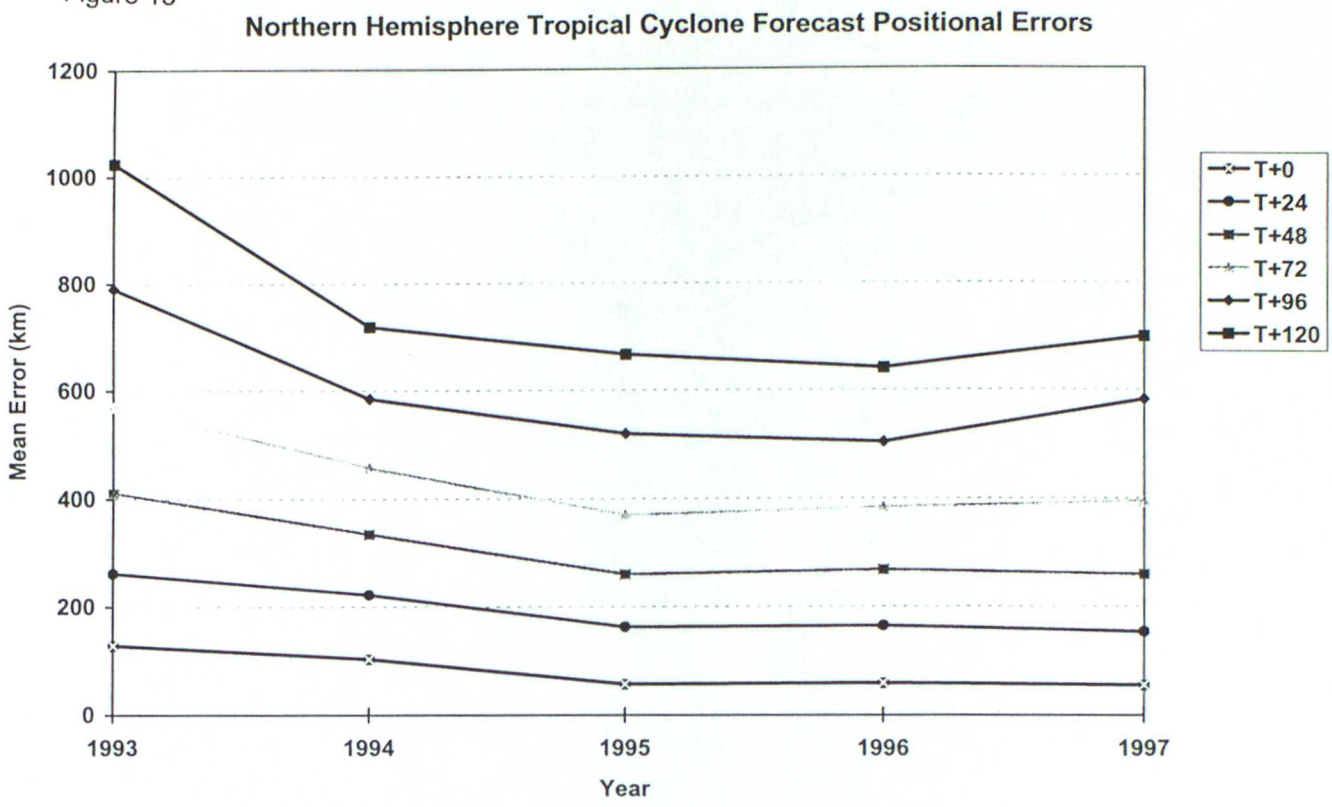

Figure 14

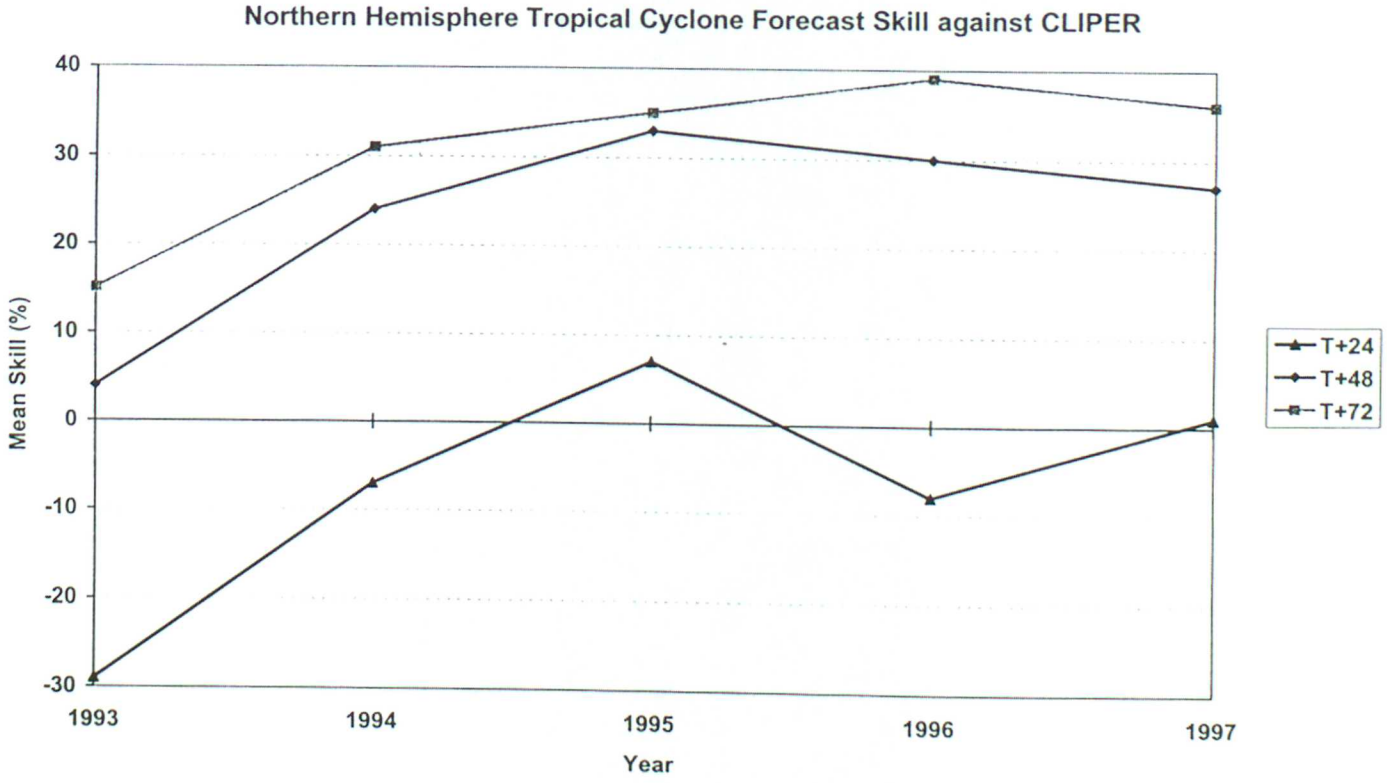

Figure 15

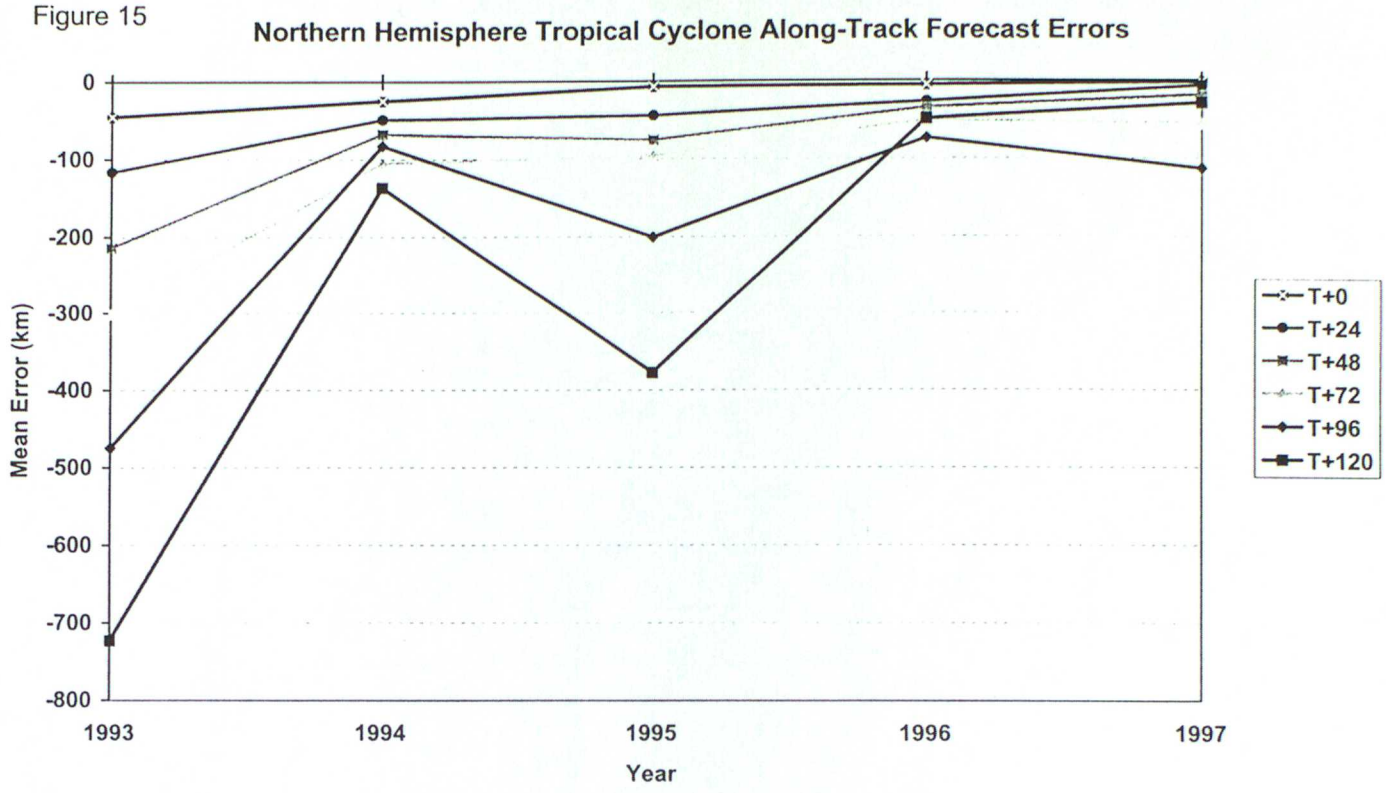

Figure 16